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Original Article

COMPARISON OF STUDY ON HORIZONTAL DISTRIBUTION OF PARTICULATE (PM_{10}) IN VEHICULAR EMISSION IN AMBIENT AIR ALONG A BUSY ROAD-SIDE IN ATMOSPHERIC POLLUTION

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ABSTRACT

Horizontal distribution of particulate (PM_{10}) in vehicular emission source is now-a-days a vital point of pollution discussion. A brief but elaborative description has been narrated in the limelight of some brilliant and wide studies with scope of works on the discussion domain so that it becomes a legislative and policy-making initiatives by legalization or such that there's the particulate pollution in various case-sensitive domains of physical location to be believed on seriously and what could solve them (particulate pollution problem) by possible practical innovations/methodologies directly or indirectly to be given as close views as impending irritations to civilization in near future coming with a rapid pace of improvements and competitiveness. Different insights with causative dimensions so responsible into the pollution have been raised upon in the study to sight the actual loopholes and distributive nature of the problem. With all the possibility, new and innovative ideas have been pointed out apart from the textbook boundary - these would be in an attempt to build a future 'smarter' city model. Various future scopes belong to it. The study could be related to other pollution problems (like water pollution, noise pollution) by conceptual approaches/thought as described in. It is finally found as an accomplished study wherein entire understanding of how the pollution problem gets into the ambient air medium to the extent of the elaboration to its removal innovations. It has various outcomes like creating of 'smarter' city-model by land-use concept, layout design of vehicular pollution tracks, particulate monitoring modeling, etc. that ends to human habit improvement also.

KEYWORDS: Particulate matter (PM_{10}), Horizontal distribution, Vehicular pollution, Pollution combating approach, Particulate removal innovation, Smarter city-land model generation, Pollution control equipment by innovation.

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INTRODUCTION

Particulate pollution is one of the severe pollutions in air pollution discussion. It has variety of dimensional formations and effects. With urbanization, it has become a great concern of various city planning organizations to make a control over this. It is common to hear now in modern days civilization the energy efficient building, L.E.E.D rated infrastructure, etc. These are with this intention that the civilization can not be stopped, but it should be with greater applications and spectrum of technology, advancement, innovations and methodologies to keep a pace with "controlled" pollution level[(I)]. Not only this, on the coming days ahead several new models are on the thought process to design city planning into a **smarter** city from its just 'smart' tag by implementing challenging and competitive designs and layouts in the city planning. Objective of such planning is always to establishing such layout planning arrangement on all through so as to create an air pollution mitigation system within itself[(II)]. Removal and control of the pollution minimization system should include various pollutants to be under observation and consideration. Theme of particulate pollution of this present study is one among them.

Types of Particulates[(I)]:

- **PM_{10}:** This is higher sized particle and belongs to an aerodynamic diameter of less than or equal to 10 micron in size dimension. It has various bad impacts on human health like bronchitis, asthma, skin rashes, and other respiratory diseases. Due to higher size and specific gravity, they can not go greater path but with the various atmospheric causes (wind speed, temperature, humidity, thermal inversions, etc.) they could be found at longer distances than they're expected. Behavior study of it is the subject point of discussion of this study.
- **$PM_{2.5}$:** it is lighter in weight (specific weight) and smaller in sizes. It has size dimension of less than or equal to 2.5 micron. By comparison, it is less than 3% of human hair diameter by size dimension. Owing to its smaller sizes, it can go much deeper than PM_{10} into human respiratory system, even inside human lungs well upto alveoli, besides the flowability to go longer distances spatially.
- **Ultra-fine particles (PM_1):** These are very fine particulates less than 2.5 micron in aerodynamic diameter in size dimension. It prolongs the settling of itself because of its lower specific gravity and weight (dead weight).

Sources of Particulate Pollution

Various sources are pointed out by several studies to mark the particulate pollution imposed by PM_{10}:

- Road dust.
- Re-suspension of road dust[(III)].
- Vehicular pollution.
- Particulate transport.
- Industrial.
- Fossil fuel burning, fireworks[(IV)].
- Climatic/seasonal changes.

- Local shops and agricultural activities(V).
- Shortage of vegetation coverage.
- Atmospheric (like solar radiation, inversions, etc.).

How Particulates do take the birth?

As described the possible sources of particulate matter in ambient air quality it is evident that particulates form itself by a conversion and mechanism from gaseous state to coarse particle through various formations of the mechanism process. Size ranges and varies as the transformation takes place to the particulate realization. There are three modes – nuclei mode, accumulation mode and coarse particulate mode (Figure 1). All the modes have individual mechanism of removal and separation from the ambient air mass. In other words, each of the modes has atmosphere-specific formation and corresponding removal(VI). Interestingly, a specific atmospheric pollution by particulates is significantly characterized and identified by the specific mode of the particulate formation mechanism. Figure 1 has many other implementative policy-making changes and planning-based outcomes to maintain and control the particulate pollution upto an extent of desired limit, provided the necessary arrangements could be provided to the 'concerned' location.

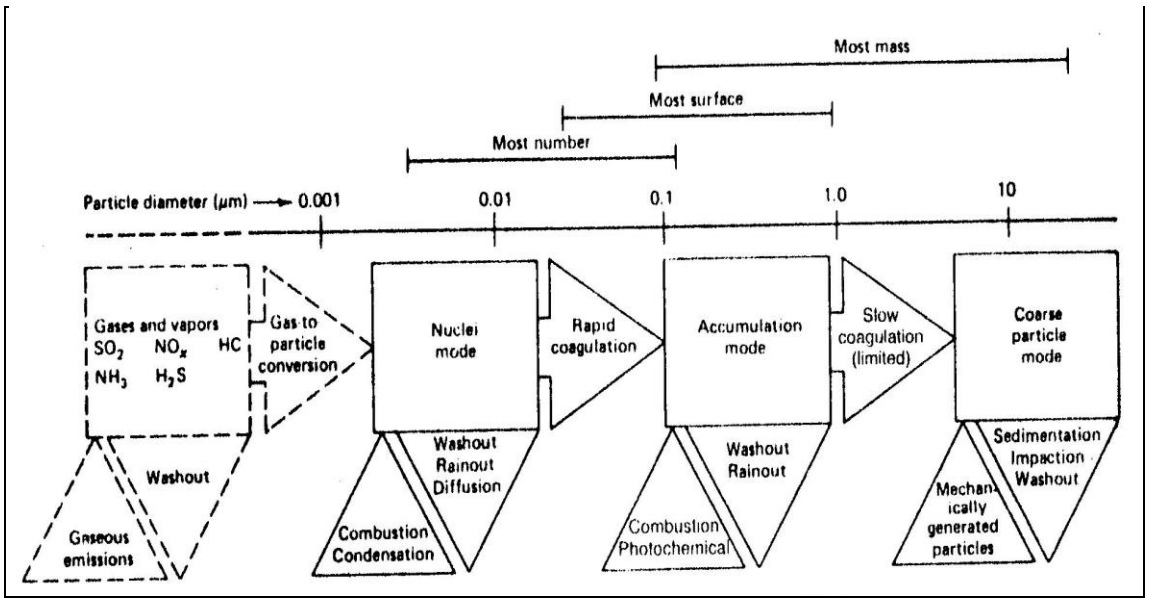

Figure 1: Mechanism of Particulate Formations (Source: Ref. VI)

What is PM_{10} Pollution?

It may be described as status of air pollution of a location influenced by spatial particles or spatially borne particulate matters that belong to PM_{10} by definition. Intensity of such pollution depends on pollution sources by kinds and atmospheric(VII). Fundamental nature of this type of pollution gives us the knowledge that it (pollution Intensity) decreases with increasing distances from its source/point of generation(VIII). The range or region within which such particulate moves and settles down is the major range of such type of pollution. It can also enter into indoors (places like bed rooms, dining, corridors, etc.) of houses, buildings, offices, etc. It may move up along vertical height of building structure depending on pollution(IX). Intensity, easeness to go beyond ABL (atmospheric boundary layer)(X), formation of flux near ground-level, structural obstructions, and many other reasons. It may not

move beyond a reasonable height of human health concern but it causes severe damages for its 'thick' presence around the human receptor zone/height which is average human height.

PM_{10} pollution is highly a subject of discussion at the places subjected to either one or more than one in combination of the following:

- Places of inversion.
- Places of wind turbulences, wind vortices, etc.
- Places of 'bad' street canopies.
- Congested areas.
- Places of lesser vegetation coverage and crop fields[(XI)].
- Places of frequent 'structural' obstructions.
- Industrial areas.
- Places of street intersections.
- Places of closed tunnel-like busy roads.
- Unnecessary road-side shops here and there.
- Old city layout improving to "smarter" layouts in recent times.
- Places with old version vehicles and policies.
- Places with little care about and lesser numbers of monitoring stations of air quality.
- Places of sensitive areas (hospitals, old-aged rest houses, schools, etc.) leaded by congestions by nearby market
- places, industries, unplanned city layout planning, etc.
- Fuel adulterations.
- Unnecessary open spaces to encourage the pollution to go further distances.
- Uneasy feeling to wear dust-free masks.
- Rising numbers of plying vehicles.
- Awareness to the pollution as well as its problems/mitigation measures.
- Policy making deficiency to "green" mode of all 'possible' parts of the pollution. Ex. Green Building.

Effects of Particulate Pollution

The pollution has fundamental effects as follows:

- On Human Health (aspects like infants, life expectancy, mortality rate, etc. are affected by PM_{10} pollution)

- On Vegetation and Agriculture
- On Structures (they are smeared by or layered with oily substances resulting to structural disintegration)
- On Industrial Infrastructures
- On 'Sustained' Air Quality as caused by ‘existing’ various disturbances like mine blasting(XII)
- On Ambient Vehicular Population
- On Climatic Disorders

How Particulate Pollution Spreads?

It is highly vital to spreadability concern of the particulate pollution(XIII). Generally, PM_{10} particulates after their formation spatially do not move much and hardly travel longer distances like PM2.5 particulates. They move lesser distance and settle down to deposition either by gravity or inertial impaction. On a given atmospheric, this type of particulates is found with lesser concentrations on increasing "horizontal" distances away from its (pollution) source. Except some special situations, these are usually found with higher concentrations within 100m from its source(XIV). It is considered that spatial distribution of the particulate pollution is occurred by statistical distribution of P.D.F (probability density function). By the fact of normal statistical distribution, there may be skew distribution on the whole out of which some portion (within itself) should be of Standard normal distribution by kind. This illustration is completely imaginative and to the assumptive conclusions of this study.

Various studies have been compared in this study to arrive at a firm conclusion about how it originates, distributes and settles to the rest, as a final removal from atmosphere. Seriousness is multiplied while heavy metals are found to be present in the pollution samples of some experimental studies(IV). Carcinogenic concerns thereby find itself into this type of pollution problem prevalence. It is not a matter of concern though to find out the responsible facts/probable generating points of socio-demographic value behind such presence in ambient air quality instead of the academic targets to be accomplished.

Let's start the description right from here, in details.

OBJECTIVE

- To illustrate various dimensions in the domain of understanding of the particulate, PM_{10}.
- To find out a conclusive stance of the horizontal distribution over distances of the particulate.
- To lay the future scope and challenges by the study and towards making better human civilization.

METHODOLOGY

Here is described various studies which show and delineate the horizontal distribution of PM_{10} on increasing horizontal distances alongwith several features of characterization as well as the settling conclusions of the particulate matter in the study. Though there are huge collections of the study in relation, some of them are given in the following:

Thakur et al. (2006) Study[XIV]:

It is the study in which the concentration of PM_{10} showed with results of decreasing pattern with the horizontal distances. Also, chemical analysis of the study gives the information of existence of heavy metals (Cd, Pb, etc.) in the particulate samples.

Ch. Monn et al. (1997) Study[XV]:

In the city of Zurich, horizontal distribution measurement of PM_{10} was determined and found with the results that PM_{10} concentration decreases as the distance increases. It is shown by Figure 2. The study shows there is the decreased level of concentration of PM_{10} found during winter than summer season.

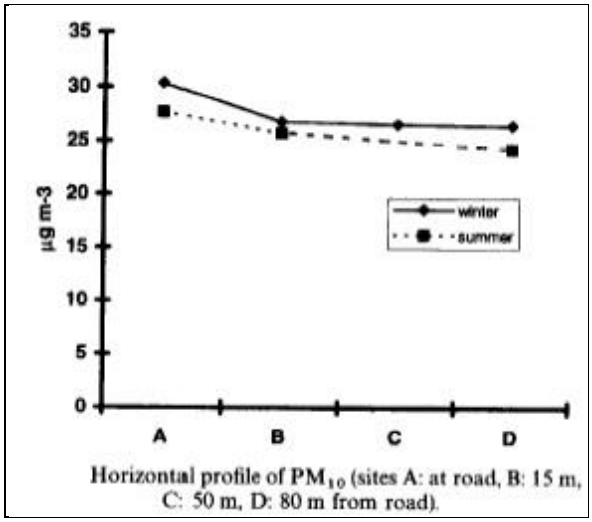

Figure 2: Horizontal Distribution of PM_{10}

Roorda - Knape et al. (1998) Study[XVI]:

It is another study which provides information about the distribution of particulate (PM_{10}) behavior in addition tovarious chemical compounds like benzene so found in the particulate sample. It describes other features like $PM_{2.5}$, chemical substances about their prolific distribution on the distances as well.

Hao et al. (2002) Study[XVII]:

In this study it is measured both horizontal and vertical profiles of airborne particulates with the similar pattern of objective determination to obtain a concept over the pattern of distribution as occurred by particulate dispersion in air mass of ambient nature. Both the profiles have given competitive aspects of the 'planar' respective existences of the particulates. Also, how airborne nature gets transformed into distributive nature is well discussed in here.

RESULTS AND DISCUSSION

The various studies have, so consulted with, some extractions about behavior of the particulate. All the studies show the following as the result, conclusion and future scopes in subsequence, keeping this study's visions to be successful:

- Distribution of PM_{10} is found decreasing over increasing horizontal distances from source location.
- Heavy metals are found in the particulate sample study.

- PM_{10} as of heavier weight do settle within few meter of the distance.
- Equipments are to be RDS (Respirable Dust Sampler)[XVIII] to collect the PM_{10} sample and AAS[XIX] to determine heavy metal.
- Atmospheric variables do always offer the range of the settlement distance of the particulate.
- The distance to settlement of PM_{10} is climate and geography centric.
- Human activities, if local to the sampling locations, cause increase in the particulate concentration, thereby leading false anticipation.
- Vegetation coverage plays environmental often less emphasized than the study location structure.

In now-a-days' human life activities, it is a continuous effort to solve various challenges as caused by the particulate pollutions. Here is given some innovations that could mitigate and solve the pollution problems as well.

How to Remove Particulate Pollution?

In order to eradicate particulate pollution besides applying traditional control equipment devices, air quality modeling also needs to be implemented. Eradicators in use/application in air pollution field are discussed as follows:

- **Electrostatic Precipitators (ESP) -** this is the control equipment of pollution of particulate of smaller sizes. It is based on ionic attraction principle of ionic metals. It is often used in stacks at the exit.
- **Gravity/Cyclone Separators –** Both the principles (gravity + inertial impaction) of particulate settling are the basis of functioning of this type of equipment. It usually removes higher sizes (PM_{10}) of particles.
- **Fabric Filters –** These are often used in industries and procession units, worked on spraying applications of water on removing the particulates from influent gas. Gaseous substances or fine particles are removed by it. It is also known as bag-house filter of air pollution control equipment. It has various forms as available in markets[I, VI].
- **Advanced technique** – There are several equipments that are coming on in near future by applying innovative techniques and methodologies. So, it is a field of continuous upgradation in order to remove the pollution in a way as suitable to human civilization.
- **Modelling (Air Quality)** – Initiatives to be given much awareness should preclude government awareness by variety of policies to the pollution problems. Sufficient number of monitoring stations should be spreaded across the city to monitor PM_{10} and other gaseous substances[XX]. With the pollution inventory locational features (like land-use, etc.)[XXI] should be added to in order to chalk out and arrive at the decision of what could be the best location layout to control over the particulate distribution. These would finally lead to air quality modeling[XXII] to totally make an overall scientific perception and realism decisions over the particulate removal. This provides practical realm of various scientific applications and data inventory knowledge.

Apart from the all these, following innovative descriptions which are one of the core of this research paper all through though are hereby given to the aim fulfillment of the air pollution reduction from ambient reception of airs at human zone.

Innovations that could be applied reduce the particulate pollutions would be as follows wherein scopes are enormous and unending:

INNOVATIONS TO REDUCE THE PARTICULATE POLLUTION

Direct Use

- Provision of transport vehicles by **'frequency by adequacy'** by numbers/density
- Air Cleaning Truck (by **drone application/router technology**)
- Air Filtering Shield (**fixes the atmospheric travel** of particulates from atmospheric layers to layers)
- PM Protective Mask (**light-weight mask** like Nasomask)
- PM Suction Pump (to be placed along the road corners/at a height suitable **grab in by suction**)
- Air purifier protection with filter arrangement (especially, **on sensitive places**)
- Road design (especially, the **intersections** of road)
- Divider allocation and kerb design facility by **suitable location layout**
- **Restricted human habits** (especially, adjacent to road): small shops like tea, snacks, etc. should be prohibited near the road. Ban on smoking on pliers, commuters, pedestrians, etc. should be particularly on road strictly.
- **Decrease** of global warming gases to release
- Use of electricity instead of oil as **vehicle fuel**
- **Initiatives** by government
- Green Building **Structure**
- Vehicular **engine mechanization** by upgradation (like carburettor initiation)
- Implementing **Afforestation**
- Energy **efficient civilization**

Indirect Use

- **Artificial Rain Technology** (to particle removal)
- **Recycle and reuse** of wastage products of gardening and others to in-house applications
- Road-side **Plantation**
- **Turn off lights** to reduce the air pollution
- Implementation of solar car to **avoid vehicular emission**
- Growth of **indoor plantation**
- **Use of natural sunlight** by reflector arrangement outside without opening window/window glass
- No to **plastic bags** (use of paper bags instead)

- Simultaneous increase of using of air cooler, fans instead of air conditioners with the decrease of bad habits/occurrences like smoking habits/forest fires.
- Avoid **cracke**rs during festival, ritual, wedding.
- Avoid using of **products with chemicals** (especially mining blasting, tillage of cropping) as it may create the pollution with severe health damages.

CONCLUSIONS

- Pollution in areas subjected to various pollution sources often creates the distribution by ambient atmosphere[(XXIII)].
- Particulates along the vertical distribution have the significant impact on the horizontal distribution as there are always various atmospheric layers (along vertical) causing disturbances to ground-level dispersions of horizontally distributed particles[(XXIV)].
- Finding and presence of carbon content in particulate sampling is great concern on all living and inert substances[(XXV)].
- Again, another substance, benzene, is often found in urban pollution atmosphere and that is very severe as it has the tremendous potential of conversion of particulate characteristics by chemical conversion process which is carcinogenic by nature to human health and to other living instincts, and also to civil engineering and metallic structures[(XXVI)].
- Vertical wind speed helps to disperse and affects the horizontal distribution as well.
- Pollution problem by vehicular source is getting upgraded by years after years. Bharat Stage (BS) is one the examples in the scenario. The pollution from motor vehicles can be minimized by structuring street canyons at the pollution-prone locations/areas[(XXVII)].
- Location layout should be guided by well-thought designs and prudent modelling indeed which often need to contribute effect by providing vertical structures on the wind scenario at the location[(XXVIII)].
- Concentration of particulate is in the future time ahead is going to be increasing with rising in number of vehicles on Indian roads which is quite disappointing with regard to air quality[(XXIX)].
- Road configurations in India are different, so difference is its ability of diffusion of particulates. So, land-use models should be applied in modelling air quality structure on location basis.

FUTURE SCOPE

- Study of three-dimensional distribution patterns of air pollutants becomes easier with the help of advanced technique of particulate measurement and monitoring[(XXV)] and that could enhance roadside emission dispersion models with maximum effectiveness in operation.
- Visible evaluation map might be helpful in studying the distribution with possible anticipation[(XXVI)].

- To avoid congestion as well as easy release of the particulates, an exemplary street design layout is to be the street canyon [(XXVII)] which could be applied to the zones of necessity as by the urban planners to the city planning and urban development system.
- Source apportioning may be achieved successfully using sensors where kind of particular method like light scattering method may be applied [(XXVIII)].
- Monitoring stations need to be installed at every 3-5 kilometre distances (depending on ambient air status by quality) keep the air quality to a standard level of city-pride.
- Proper apportionment of pollution sources is vital to the modelling success. It may be otherwise to specific turbulences[(XXX)].

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